Numerical Studies on Laser Welded Top-Hat Column under Axial Collision Based on the Concept of Super-Folding Element

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Abstract— *Extruded longitudinal double-skinned aluminium body plates with integrated stiffeners are recently used for manufacturing in automobile industry like front rails and railway carriages. These extrusions provide light and heavy rigid structures. However, since it is not feasible to produce large parts by extrusion, these plates need to be connected, mostly by welding techniques. The crashworthiness performance of laser welded columns is evaluated using finite element (FE) analysis. This is very important in automobiles, since more attention is being paid to crashworthiness of the structures in recent years. The analysis method is based on the Superfolding Element (SE) concept, which originates from experimentally observed folding patterns of crushed shell elements. The FE model is used to predict accurately the progressive axial collapse of the lased welded columns and impact strength is greatly improved by laser welding technique.*

Keywords— Crashworthiness, Laser welding, SEA, Superfolding, Top hat

I. INTRODUCTION

One of the major challenges of the automotive industry is to reduce the structure weight, leading to a decrease of the CO_2 emission. During recent years, the car body assembly techniques were dominated by laser welding. When using Aluminium in the body structure of a vehicle, weight savings of as much as 25 % may be possible compared with conventional steel structures, which will reduce fuel consumption [1]. What's more, aluminium alloy has good corrosion resistance and high capability of energy absorbing. Crashworthiness of aluminium extrusions is affected by material microstructure, loading speed, and geometrical dimensions [2]. A motivation of this work arises from the various types of hat cross-section column members are extensively used in vehicle applications and play an important role in absorbing kinetic energy during a collision [3]. In general, the car front rails are made from single-hat elements. Therefore, it is necessary to understand their axial crushing behavior for the structural design of a vehicle and ultimately to reduce the likelihood of passenger serious injury in an accident [4].

Laser beam welding (LBW) will be a vital joining technique for thin steel sheets with their increasing applications in aerospace, aircraft, automotive, electronics and other industries. LBW is a modern welding process used to join multiple pieces of similar and dissimilar metal through the use of a laser beam. The first step in laser welding is laser absorption. The absorbed energy is transferred into bulk material by conduction. The laser energy absorbed by the material starts to heat and melts the material [5]. The body-over frame structure of a passenger car or a sport utility vehicle consists of a vehicle body, frame, and front sheet metal. A light duty truck consists of a frame, cab, and box. The vehicle body provides most of the vehicle rigidity in bending and in torsion. In addition, it provides a specifically designed occupant cell to minimize injury in the event of crash [6]. In order to assess the crashworthiness of vehicles, all major passenger car makers today employ numerical simulations as a support in the design process.

II. LBW ON CRASHWORTHINESS

Fusion welding process in which coalescence is achieved by energy of a highly concentrated, coherent light beam focused on joint. LBW normally performed with shielding gases to prevent oxidation. In this welding process filler metal not usually used. In spite of the tremendous progress achieved in crashworthiness simulations of vehicle structures from components to full-scale vehicles, using the latest techniques in computational mechanics and super computers, final crashworthiness assessment still relies on laboratory tests.

2.1 Material

Aluminium 5052 alloy is selected for modeling of top hat section and base stiffener plate. 5052 is an aluminium alloy, primarily alloyed with magnesium and chromium. Weight saving and impact safety requirements are calling for the application and structures with high specific energy absorption to vehicle and this obtained of aluminium 5052 alloy.

TABLE.1: Mechanical Properties of 5052 Aluminium Alloy

S.No.	Properties	Units
1	Density	2.78 g/cc
2	Ultimate Tensile Strength	186 Mpa
3	Yield Strength	78.5 Mpa
4	Hardness	47 HB
5	Poisson's ratio	0.33

2.2 Geometry Dimension:

Top hat section and stiffener base plates are modeled using Abaqus.

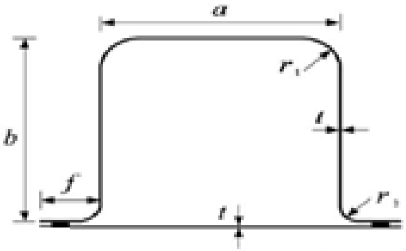
Dimensions	Geometry
Wall thickness(t)= 2 mm Width(a)= 50 mm Width(b)= 50 mm Height(h)=200 mm Flange(f)=15 mm Inner radius(r_1)=6 mm Outer radius(r_2)=4 mm	

Fig.1: Geometry Diagram

III. CALCULATION OF ENERGY ABSORPTION PARAMETERS

3.1 Specific energy absorption (SEA)

SEA is one of the important performance indicators in energy absorption devices, particularly when considering weight reduction. It is a ratio between absorbed energy and the mass of the specimen.

SEA = Absorbed Energy/Mass = 1335.398/260 = 5.14 J/g

3.2 Mean crushing load

It is the mean of the values of the applied force, which fluctuates along the test. It can be obtained as the ratio between energy absorbed and total displacement of the crushing length.

Mean crushing load = Absorbed Energy/ crushing length = 1335.398/66 = 20.23 k

3.3 Load Ratio (LR)

It is the ratio between initial peak load and mean load.

LR= Initial peak load/Mean load = 64/20.23 = 3.164

3.4 FE Analysis in Abaqus

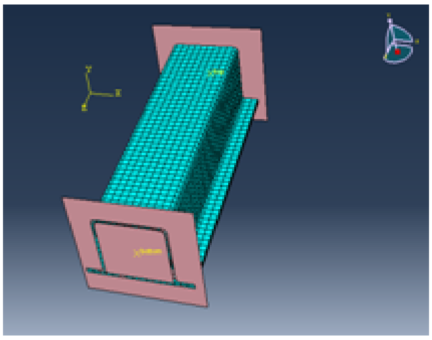


Fig. 2: FE Mesh Model

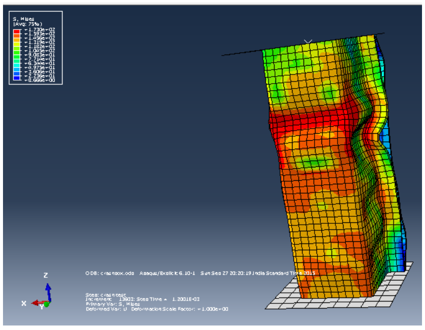


Fig.3: Crushing at 10 mm displacement

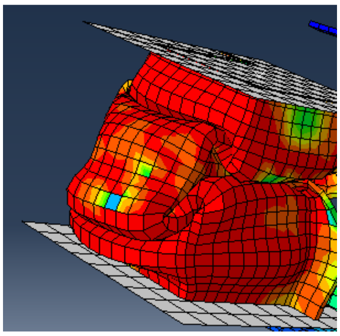


Fig.4: Crushing at 66 mm displacement

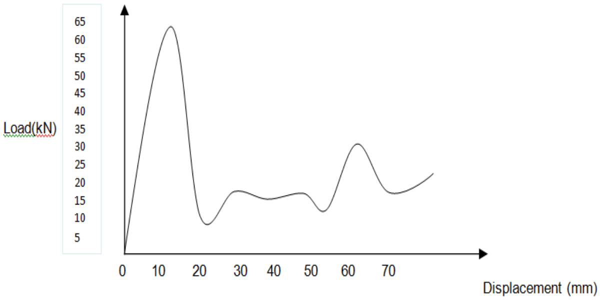


Fig.5: Load–crush displacement responses

IV. CONCLUSION

In today's quest for continued improvement in automotive safety, various restraint systems have been developed to provide occupant protection in a wide variety of crash environments under different directions and conditions. The primary discussions on the vehicle/occupant response in frontal impact analysis only, even though side crash events are lightly touched upon. Axial crushing behavior of hat-type Laser-welded columns has been studied numerically. The robust numerical model can be effectively used to predict the crashworthiness efficiency of hat-type column specimens prior to conducting the actual axial crush test. Aluminium 5052 alloy are considered ef fective in improving crash safety and reducing the weight of automobiles.

REFERENCES

[1] M.Langseth and O.S. Hopperstad, "Static and dynamic axial crushing of square thin-walled aluminium extrusions", Int. J. Impact Engng, Vol 18, Nos 7-8, pp. 949-968, 1996

[2] Fyllingen Ø, Hopperstad OS, Langseth M. Robustness study on the behavior of top-hat thin-walled high-strength steel sections subjected to axial crushing. International Journal of Impact Engineering 2009; 36(1):12–24

[3] Huang, M., Vehicle Crash Mechanics, CRC Press, 2002, pp. 67-83.

[4] Huang, M., "An Analysis of the Vehicle-Occupant Impact Dynamics and Its Application," SAE Paper No. 830977, 1983.

[5] A Review of Laser Welding Process for Thin Steel Sheets, Dhaval K. Soni et al. / International Journal of Research in Modern Engineering and Emerging Technology.

[6] Vehicle Crashworthiness and Occupant Protection, Sponsored by: Automotive Applications Committee American Iron and Steel Institute Southfield, Michigan